Recent Trends in Implementation of Internet of Things – A Review

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***Abstract*—As of 2016 due to a convergence of multiple technologies ranging from wireless communication to the internet and from embedded systems to micro-electro mechanical systems (MEMS) the prospect of "internet" of things has evolved. This means that the traditional fields of embedded systems, control systems, automation and others contribute to enable the internet of things.**

The Internet of Things (IoT) is a network of intelligently connected devices communicating together. With the help of such an interconnected smart global network one can make lives much easier and safer. It provides us the ability to sense and control objects remotely across pre-existing network infrastructures creating new opportunities for a more direct integration of the physical world into a cloud based system. This results in improved accuracy, efficiency and economic benefit for today's society.

Keywords—IoT, Intelligently connected devices, Cloud system, Network, Automation.

I. INTRODUCTION

Internet of Things (IoT) [1] refers to a network of smart devices communicating and exchanging data with other machines, objects, devices and environment around the globe. By augmenting IoT with sensors the technology becomes an instance of virtual physical systems, allowing physical and software components to be deeply connected with each other, operating on different spatial and temporal levels. This helps in interacting with each other in various ways that change with context, exhibiting multiple and distinct techniques. Such a cyber-physical system [2,3] thus encompasses technologies such as smart homes, smart grids, smart cities and intelligent transportation.

In 1999, Kevin Ashton in context of supply chain management, coined the term Internet of Things. However in the last decade the definition has expanded from sheer automation to a plethora of new application areas like healthcare, transport, utilities, etc. This thus lays the groundwork for a drastic evolution into today's Smart City and Smart Energy Management Systems. Ever since the internet revolution, the interconnection between people and the objects grew exponentially and thus the birth of the Internet of Things was inevitable.

In today's world it is mandatory for every organisation to have information centres to provide suitable information to people. In an educational organisation it is of utmost importance for a member to receive notifications regarding rescheduling of events and announcements in time. A healthcare environment requires quick flow of information, storing data of hundreds of patients and performing analysis in real time to provide proper patient care and safety. But for such systems to work efficiently it is important to have trained personnel who are constantly updated with such information. To make this tedious process more efficient and economical, one can always rely on automation. By making IoT the solution, we allow

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technology to be responsible for answering all of the queries asked by people.

In a world where IoT is no longer just an idea, consider a scenario where John just received an email from his boss where he has to go to Geneva for a conference four days from now. His smartphone suggests him a suitable air ticket and accordingly reschedules his appointments for the week. Considering his previous preferences it also suggests a hotel reservation for his trip. His smart wardrobe scans the RFID tags on his clothes and taking into account the weather conditions in Geneva during his stay looks up jackets of his preference on Amazon. One day before the trip his smart device gives him a notification for packing and recommends him a list of items appropriate for his commute. His smart watch sets a reminder and wakes him up three hours before his morning flight. When the alarm goes off at 6:00am, it immediately notifies his coffee maker to brew a cup. Based on the traffic situation in Kolkata at that time it also books an Uber for him. On his way to the airport he remembered that he forgot to turn off the AC in his room but he doesn't have to worry about it, his smart home management system took care of it knowing he left for his trip. As soon as he cleared his security check he got his digital boarding pass. Next thing he knows, he is on his way to Geneva hassle free.

In this scenario, every aspect of John's daily life has multiple sensors and actuators. He is not interacting with his smart device all the time to direct these inter-connected things to take necessary action even though it is a gateway for his activity. In this tomorrow millions of people will be doing this every single day. We will be living in the data.

As mentioned in [4,5], IoT is expected to transform how we live, work and play. From factory automation and automotive connectivity to body sensors in our garments and home appliances the authors talk about how it is going to touch every dimension of our lives. Cars that sense each other to avoid accidents will make our lives much safer, automatic daylight sensing lighting systems will make our lives greener. Even smart wearable which can detect heart attacks and strokes before they happen can make our lives better. The applications we are talking about is a long road ahead from the IoT of 2016. Only in 2011 did the number of interconnected devices on the planet overtake the actual number of people. Currently there has been an exponential increase in the number of interconnected devices and it is expected to reach 50 billion by 2020. For IoT to change how we live and work we need billions of such data sprouting devices to be connected to the internet.

II. RELATED WORKS AND TECHNOLOGIES USED

The development of ubiquitous computing system where digital objects are able to think and interact with each other to collect data on the basis of which automated actions are taken, requires the integration of new and effective technologies [6].

An overview of the enabling technologies for IoT is:

1. Near Field Communications (NFC) and Radio Frequency Identification (RFID)

In the 2000's RFID was the key technology for making the objects uniquely identifiable [7]. It is the wireless use of electromagnetic fields using radio frequency to transfer data while automatically identifying and tracking tags. The tags can be both active and passive, active tags have a battery attached to them for continuous emission of data signals whereas passive tags just get activated when they are triggered. Today this technology is revolutionizing the way we communicate from simple objects such as passports, library cards or advanced business applications such as asset tracking, livestock identification, RFID is finding its applications [8]. NFC is an offshoot of RFID and much like latter, it enables one way communication. Although they share similarities, NFC is designed for use by devices within close proximity (generally 5 cm or less) of each other. It is designed to be capable of being both a NFC reader and a NFC tag allowing it to communicate peer to peer, setting it apart from typical RFID devices. NFC plays a critical role in the transition of connected living, providing new levels of convenience and interaction. NFC enables appliances to do more. For example, setting the washing machine becomes as simple as opening app on your tablet. As of now, there are 500 million NFC enabled devices in the market.

2. Cloud Computing

With millions of devices expected to come by 2020 (according to a survey by the research firm Gartner), the cloud seems to be only technology that can analyse and store all the data effectively. Cloud Computing not only converges the servers but also analyses the useful information obtained from the sensors and even provide good storage capacity. But this is just the beginning of unleashing the true potential of this technology, if properly interfaced with millions of sensors, cloud computing can be off enormous benefit for a large scale development of IoT.

3. Bluetooth Low Energy

This is one of the latest technologies for implementing IoT. There are some good reasons to use Bluetooth as the backbone because of the easy availability and user familiarity with this technology. BLE is designed and marketed by Bluetooth Sig. Tags based on BLE can signal their presence utilizing more energy enabling them to run on standard coin cell batteries for years.

With the incessant proliferation of the emerging IoT technologies, the concept of Internet of Things will soon be inexorably developing on a very large scale. In this paper we presented the applications of IoT which facilitate us in our daily lives. However no such omnipresent technology is free from challenges in its development. The deployment of IoT requires strenuous efforts to tackle and present solutions for the emerging problems.

In literature [9] the authors spoke of a situation where a patient's medical review, vital parameters and dialysis machine inputs are recorded with the help of medical devices augmented to his/her body. Data gathered from these devices are analysed and stored, and aggregation from multiple sensors gives us valuable insights for taking timely actions. Caregivers can get real time insights of patient's condition and respond appropriately leading to better clinical outcomes. In order to implement such a context aware, intelligent, health and wellness system that provide relevant patient specific alerts, there is a need for a service oriented architectural approach. Such a SOA platform not only needs to integrate data from medical devices like blood-pressure monitors, glucose monitors but also other sources of patient specific contextual data which includes mobile devices. Realising techniques like semantics technology to process and correlate complex events from this data, is still a thing on paper. Secondly all this data that has to be stored and analysed is increasingly rapidly. Some medical devices such as MRI machines, X-ray machines generate high resolution multimedia output. If storage of such sheer volume of data is not managed efficiently it will lead to 'Big Data' problem. Lastly such medical data is highly sensitive and unrestricted access can be a major drawback. Another flaw in [10] is that incorrect understanding and diagnoses, due to an error in the device can lead to major health risks.

The authors of [11] talked about using RFID tags to implement IoT in everyday life. The main challenge one would then come across is integration of each and every device with an RFID tag so that it can be uniquely identified in the IoT environment. Furthermore with the increase in the number of devices applying IoT collision of radio frequencies utilised by such applications is imminent. As recounted in a report by AFSSET, the impact of electromagnetic waves emitted by RFID readers on the human body is low however there is always a risk in the long run for users undergoing continuous exposure. In recent years, a wide range of industrial IoT applications deploy RFID technology where the risk is much less because majority of the industrial systems is autonomously controlled without much human intervention.

[12] talks about developing a system that will autonomously monitor and automate all of the processes. Alert detection and taking timely action under such circumstances manually is a time consuming and inconvenient approach. However, by implementing Wireless Sensor Networks (WSNs) together with the Intelligent Decision Making concept of IoT the aforementioned drawbacks can be overcome. This can be possible through past experience and storage of previous such similar conditions on a cloud based database. The authors of the above paper suggest implementation of sensors in wide area over the machines and instruments. Control and monitor of all these sensors by using the concept of Artificial Intelligence and IoT is a long way from large scale deployment. Lastly development of such modernised systems rely largely on pre-existing wireless networks, the efficiency of which is still not up-to the mark in today's world.

The education system is also affected by this new growing technology. The SMART classroom and E-learning utilizes IoT to provide a one stop resource for students needing research, technology and global interaction. Where distance becomes an issue, teacher-student or student-student interactions can take place simultaneously resulting in real time multimedia interactions with the help of Real Time Interactive Virtual Classroom (RTIVC). Students who participated in smart classrooms reported being 24% more engaged in class and 23% more likely to feel that communication was better facilitated. In literature [13], the authors talk about virtual field trips. While teaching, say a teacher is covering a lesson on desert animals, using smart-board, he/she could give a virtual tour of the Kalahari Desert to teach this topic. IoT thus complements present day classroom teaching with a next generation teaching aid that provides a plethora of opportunities. All that being said, such an Integrated Learning System (ILS), as described by the authors does not provide the students with the benefit of Face to Face learning experience. Another disadvantage is that, schools and colleges to be well equipped with this new technology can prove to be quite expensive, especially considering the infrastructure of developing countries.

With the ever increasing demand for power and limited energy harvesting solutions, the development of more efficient energy management systems is crucial. A smart grid updates the pre-existing infrastructure, reducing system hazards, thus meeting current safety standards while consistently avoiding power fluctuations. It also provides end users access to real time monitoring of their energy consumption. The authors of literature [14] presented a multi layered network implementing the IoT method for high voltage communication lines using optical fibre composite overhead ground wire(OPGW), general packet radio service(GPRS) and Beidou (COMPASS) .Using a combination of the above mentioned technologies the Wireless Sensor Network (WSN) allows the nodes to communicate between each other allowing stable data transfer even in the most remote areas and under extreme weather conditions.

The Internet of things (IoT) has dramatically transformed this last decade. The clock on the connected device transition is ticking very loudly and driving IoT into the world of automation. Automation will continue to transform the global workforce, significantly reducing operating expenditures. It's the next huge leap in productivity but at the same time Forbes foresees a full-on worker revolt on the horizon following this radically new economic state. Lastly in a world where everything will be connected to everything, will IoT be secure? Each connected device represents a potential point of weakness, through which hackers can gain unauthorized access. Hence implementation of proper security is of maximum priority when implementing such a revolutionary technology otherwise it will lead to total system failure. On a wider scope, IoT seems like something that would expose companies and firms all over the world to more security threats [15].

III. APPLICATIONS

The Internet of Things will utilize existing interconnected networks and augment them further with the help of newer wireless sensor technologies [16]. But where and how, in the scale of hype to reality, can IoT profit the users of today?

Let us consider some of the promising application areas of IoT technology.

i. *IoT-MD*

Remote health management, fitness programs, chronic diseases and care for the elderly – in all these spheres an IoT oriented platform can provide an improved quality of care.

a. MiMo Monitor: The Mimo monitor is a new piece of technology that is aimed at providing parents with real time insights about their baby's breathing, skin temperature, body position and activity level on their smartphones, thereby reducing the risks of SIDS.
b. Glow Caps: Glow Caps fit prescription bottles and via a wireless chip provide services that help people stick with their prescription regimen; from reminder messages, all the way to refill and future doctor consultation.
c. BeClose: Using a wearable alarm button and other discrete wireless sensors placed around the home, the BeClose system can track someone's daily routine and give peace of mind to their loved ones for their safety.

ii. *Smart Home*

IoT can help reduce the monthly bills by remotely monitoring and managing home resources.

a. WeMo: WeMo is an example of smart outlet that gives the user the ability to instantly power on and off any plugged device from anywhere across the world. Over time, this allows to save money as well as conserve energy by eliminating standby power. It also helps to increase the operating lifespan of a device through more efficient use.
b. Ninja Block: Ninja Block with its huge range of add-on sensors can track a gas pipe leak, or even serve as burglar alarm while no one is at home.
c. HarvestGeek: HarvestGeek utilizes a smart system to save ones time and resources and automate the process of keeping plants fed based on their actual growing needs and conditions.

iii. *Smart City*

IoT offers improved infrastructure, more efficient and cost effective municipal services for the modern day city thereby improving the quality of life for the citizens.

a. SensiNet: The SensiNet system can quickly calculate current consumption levels on a line and analyze that data.

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Echelon allows a city to intelligently provide the right level of lighting needed by time of day, season and weather conditions. Significant financial and energy resources are saved by using such solutions.

b. LoRa:
The Dutch telecommunications company, KPN undertook the project of fitting existing mobile transmission towers with LoRa gateways and antennas; thus, creating a network of IoT dedicated devices. LoRa WAN will eliminate the need for a local Wi-Fi connection for devices to communicate with each other.

iv. *Industrial IoT (IIoT) and Smart Agriculture*

IoT can help streamline the operation and save in resources and costs by providing newer approaches.

a. OnFarm: The OnFarm system incorporates real time sensor data of weather forecasts, moisture levels of the soil, and pesticide usage from farming sites into a simplistic cloud dashboard. Farmers can use this data to remotely monitor all of the farm assets and optimize productivity. Furthermore senseFly offers drones to automate the entire process.
b. Maintain and Repair: Sensors installed inside machines will monitor if any of the components have surpassed their designed thresholds. Service maintenance can be automatically scheduled.

v. *Smart Environment and Disaster Management*

By understanding and better managing what we currently have, IoT can send out alerts to communities before a catastrophe occurs.

a. Air Quality Egg: The Air Quality Egg is an air quality sensing system designed to allow anyone to measure NO_2 and CO concentrations outside of their home using an RF transmitter and Ethernet driven base station. The obtained data can then be shared with and utilized by the concerned bodies.
b. Floating Sensor: This project makes use of motorized drifters which come outfitted with GPS, temperature, salinity sensors and cell communication, and smart data processing technologies utilize this data to avert unanticipated events like floods.
c. Grillo: Grillo is taking advantage of low cost accelerometers and wireless modules to build affordable consumer devices that both extend the earthquake detection network and act as an in home alarm system when a quake is on its way.

As of now we still have a long way to go in the creation of an Internet of Things and the above examples provide just a small glimpse into what can be achieved when sensors, actuators and networked intelligence are combined.

IV. CONCLUSIONS

Nowadays the world of Internet is changing towards Internet of Things where all things which we use in our day to day life connect to the internet and can be monitored and operated remotely. In this paper many domains have been shown where IoT can be implemented but one must always remember that this is an ever expanding versatile domain. The IoT promises to enhance an individual's quality and boost enterprises' productivity. The pieces of the technology puzzle are fitting together to accommodate the internet of things sooner than the world anticipated. Just as the World Wide Web caught like a wildfire, it is just a matter of few years before the Internet of Things touches every corner of our lives. Merging the physical and virtual world has been a target the human race has strived to achieve for quite some time. The Internet of Things is set to create a highly personalised, predictive connection experience. In workplaces and social lives IoT has become a versant conversation topic, the concept that will be a huge impact on how we work and live. It can improve efficiency and help reduce waste of resources such as energy. Its possibilities are virtually endless and it is no surprise IoT development and its applications are a hot topic in the industry. But then something as intricate as this has equally big challenges. IoT development may be interesting in conversations, but developers have serious technical challenges to be addressed such as testing supplies and analytics for IoT applications. Lastly one of the biggest shortcomings is security. With billions of devices and things connected together on an online platform, how hard could it be to have the entire network hacked by someone with a mere laptop and internet connection.

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